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MASTER

TITLE: CAD/CAM IN THE LASL SHOP DEPARTMENT

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CAD/CAM IN THE LASL SHOP DEPARTMENT*

Elbert W. Colston

Los Alamos Scientific Laboratory

*Report presented to the Spring 1979 meeting of the IMOG Machine Tool Subgroup, April 10-11, 1979.

The LASL Shop Department (SD) had tried for several years to get an in-house computer system, primarily to support the numerical control machining unit. Finally, in 1976, in conjunction with other LASL groups, SD received funding to procure a system. The decision by LASL to procure the AD-2000 Interactive Graphics software as developed by Manufacturing and Consulting Services, Inc. (MCS) was supported by all interested LASL groups.

Since AD-2000 was designed to be hardware independent, each LASL group analyzed their own computer system needs and went out on competitive bids. SD procured an Interdata 7/32 computer system configured to handle three graphics stations, namely NC programming, design engineering and drafting, and the quality/inspection section. A Gerber Model 24 plotter/digitizer was also selected for production of drawings. Figure 1 shows the existing computer system with an additional graphics terminal and several low speed alphanumeric terminals.

An additional order was written to MCS to rewrite all of SD's APT postprocessors to run under AD-2000 on the Interdata system. This system would allow SD to be off the central computer facility.

The use of a CAD/CAM system by an operation that was primarily a job shop operation resulted in some unique problems. First, even though our two biggest customers also procured AD-2000 and the capability exists to transmit data base information via mag tape, the vast majority of jobs requiring SD interaction are transmitted on paper drawings. This requires building the part data base on AD-2000 by SD personnel in order to do the manufacturing processing. This is very time consuming since more data may be required by AD-2000 to allow NC processing than would be required by APT.

Second, our design engineering and drafting section is also a job shop function, that is, they are used by other LASL groups to augment their own staffs and only a small portion of the design effort on AD-2000 may end up as a fabrication job within SD. Thus the great efficiency of a common data base from design to final hardware is going to be missing at least initially.

One of the biggest users of AD-2000 is the inspection section. To get data out for use by inspectors, measuring machines and/or customers requires the existence of a data base, and as in the case described for the NC unit, very seldom happens. In addition, if SD's manufacuring unit builds a data base for processing, the Quality Section doesn't feel free to utilize it due to potential errors in going from the paper drawing to the AD-2000 data base.

To show examples of AD-2000 operating modes several figures from the graphics terminal screen will indicate typical operator functions.

Figure 2 is a typical parts list that any graphics system user might have on the system at any given time. Each user's file is totally protected from any other user. Without specific actions from the computer operator, no files can be transferred.

Figure 3 is a typical machine tool cutter path as generated by AD-2000 from various operator commands.

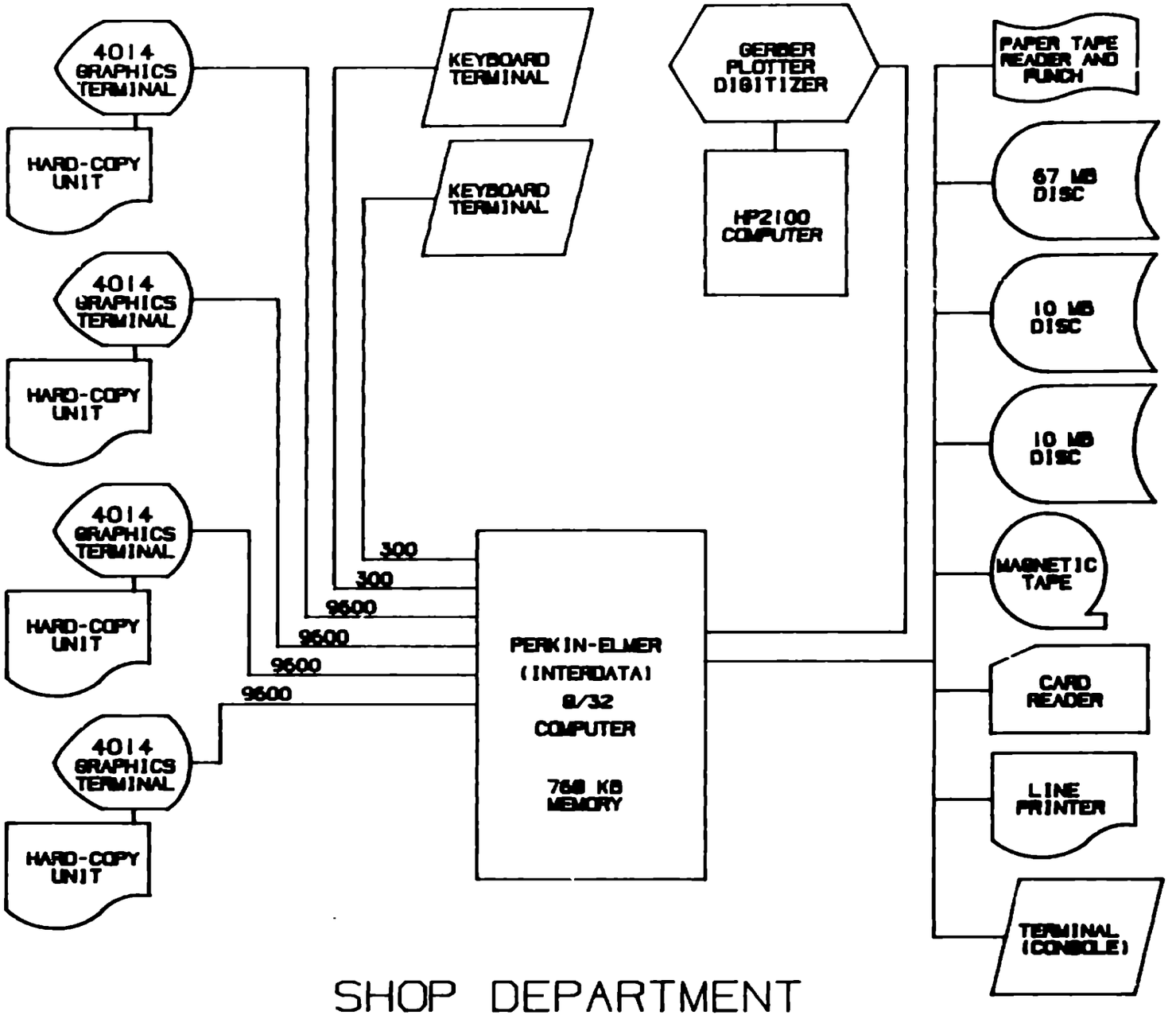
Figure 4 is a partial spherical surface with a slot as drawn by AD-2000 in preparation for 5-axis machining of the surface.

Figure 5 is a typical drawing made with AD-2000 and output on the Gerber. Figures 6-9 are AD-2000 generated magnifications from Figure 5 to show the ease of working at a convenient scale.

Figures 10 and 11 are drawings generated by using patterns. That is, a single chain link or gear tooth is designed and then using the duplication, rotation and translation features to generate a complete unit.

Figures 12-21 are examples of how the inspection group utilizes AD-2000 to get inspection data. Figure 12 is typical input of X-Y or R-Theta data from a drawing with two different sets of data. Figure 13 shows an AD-2000 curve fit using a cubic spline routine and offset curves a given normal distance away. Figures 14-21 show an analysis of the offset curves as given by AD-2000.

In summary, the use of a CAD/CAM system by a multi-function job shop operation is somewhat different than an integrated design manufacturing unit but we feel has already made significant improvements in SD's operation.



SHOP DEPARTMENT

CAD/CAM COMPUTER SYSTEM

Figure 1

PART LIST

1437 4/ 9/78

NAME	SHEET	NUMBER	DATE	LOCATION	SIZE	REL/REV
CYLINDER	1	# 1332	1/25/78	0	14592	0.00
DIE	1	# 1013	1/17/78	114	12544	3.00
GEAR	1	# 1119	1/22/78	212	18544	0.00
SPRING	1	# 0	0/ 0/ 0	310	6912	0.00
CHAIN DRIVE	1	# 1114	2/ 8/78	364	14592	1.00
CONNECTION	1	# 1130	4/ 6/78	632	19712	1.00
FLANGE	1	# 834	4/ 9/78	478	19712	1.00

HIT YES OR NO TO DO ANOV
KEY IN NAME

Figure 2

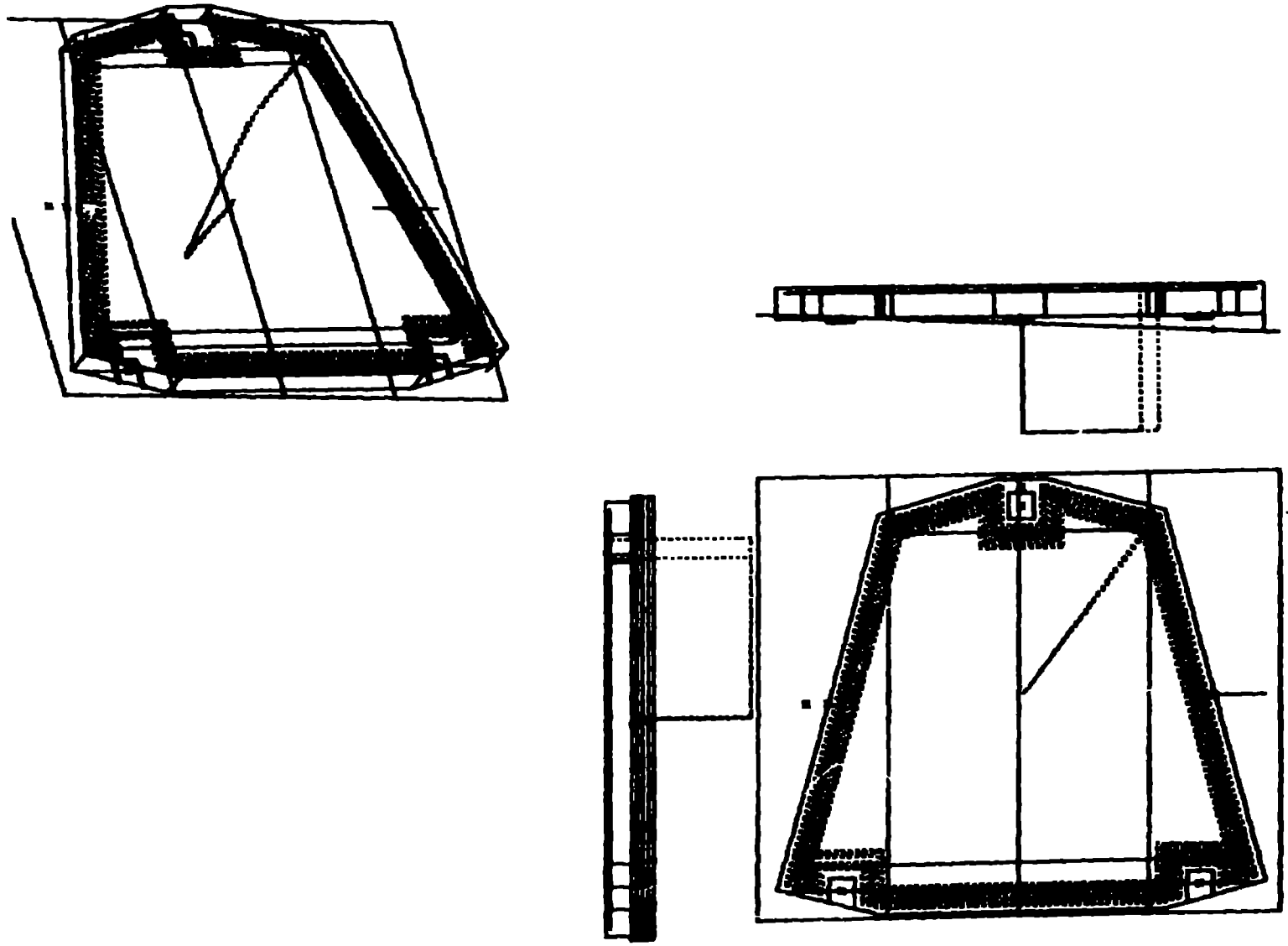


Figure 3

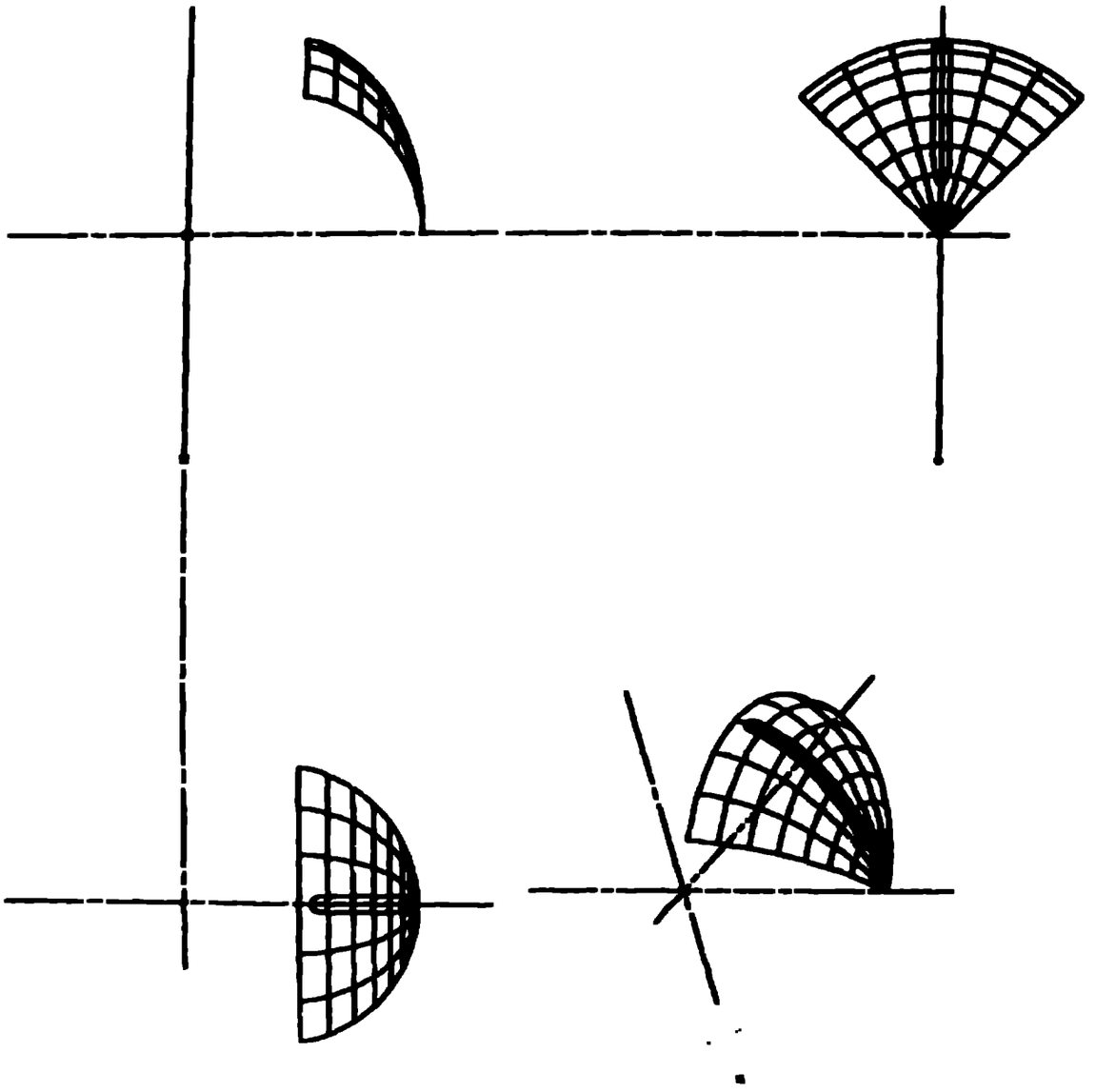
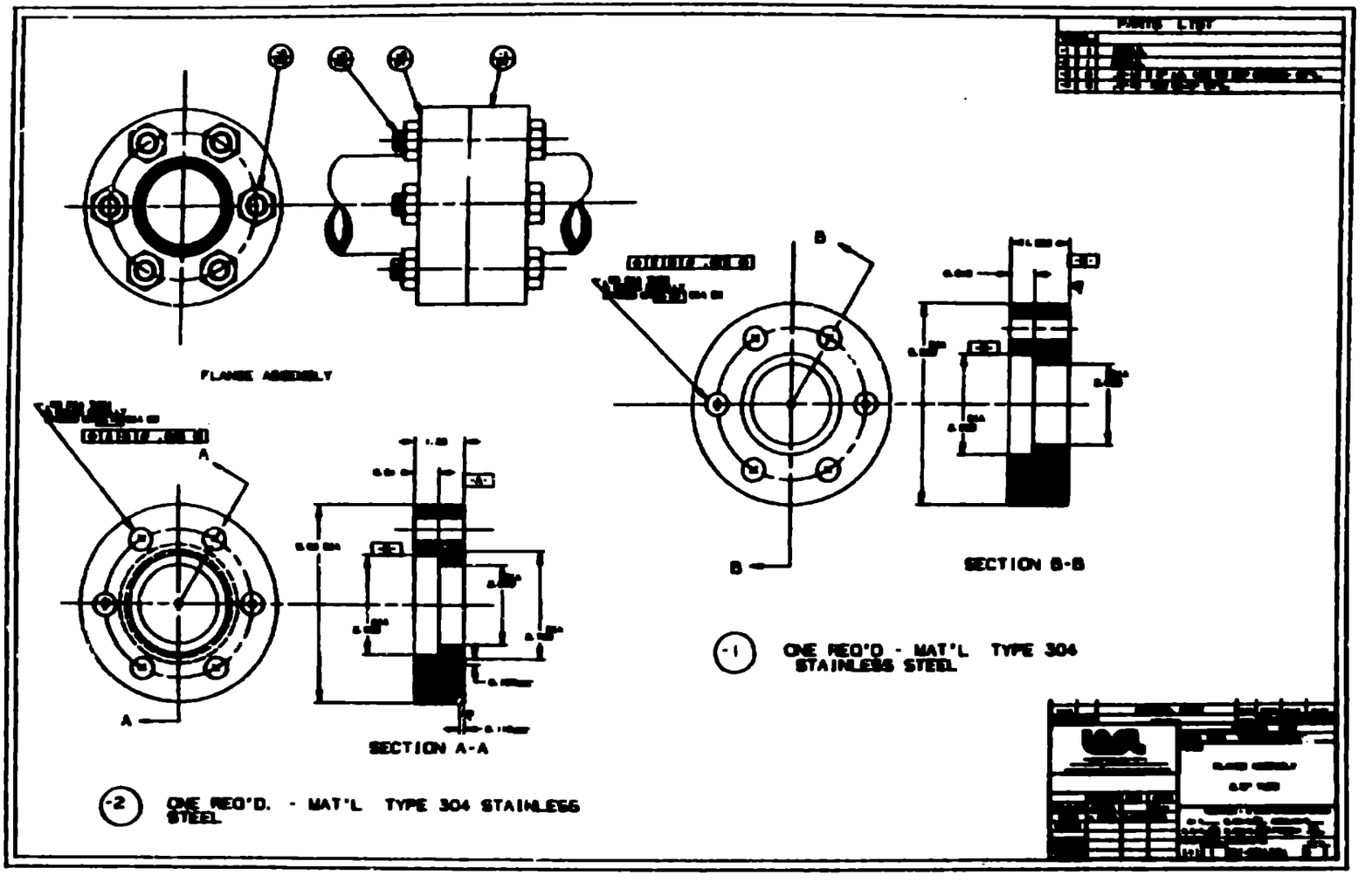
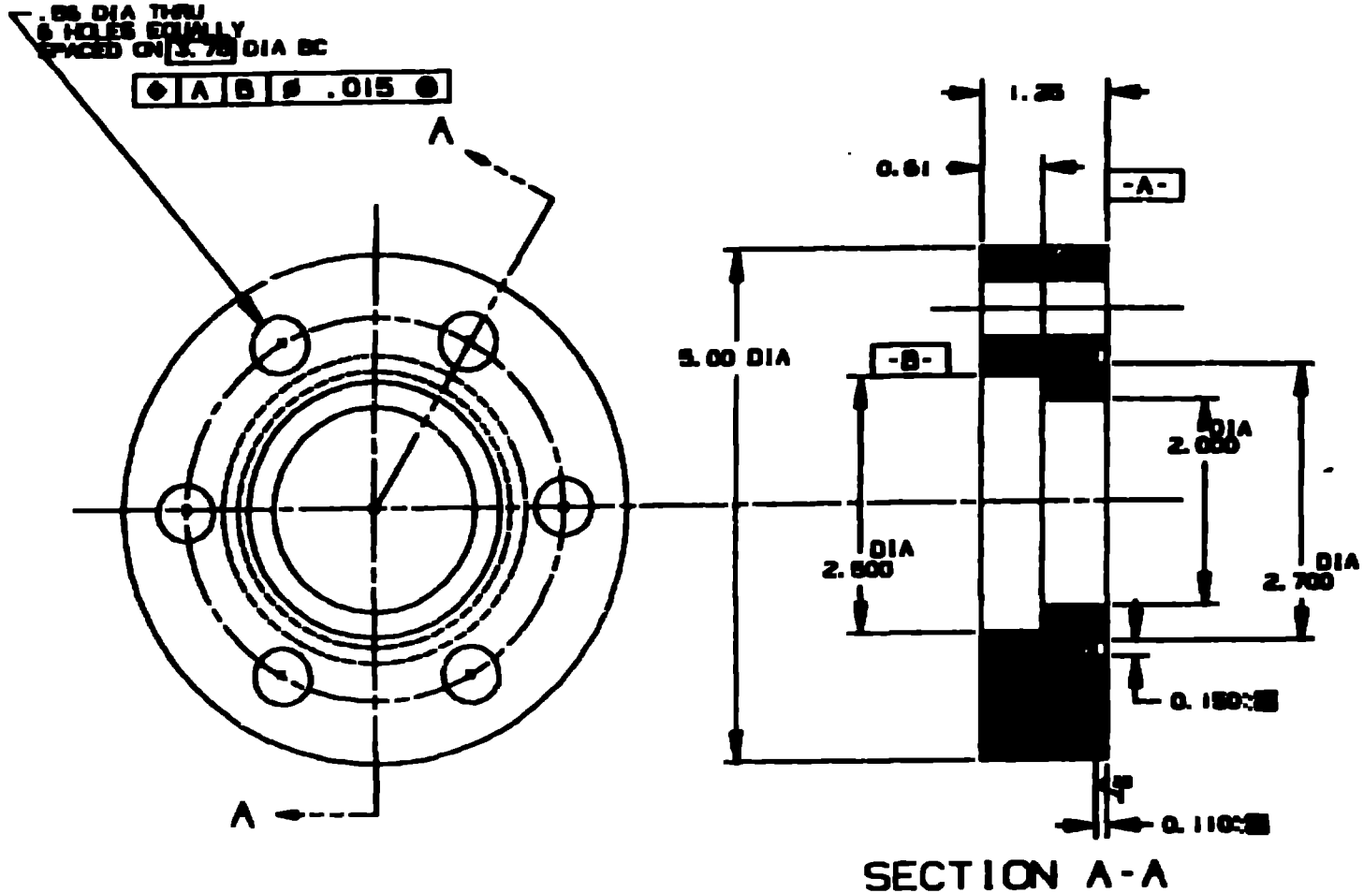


Figure 4


FLANGE ASSEMBLY
A
A
SECTION A-A
B
B
SECTION B-B
-1 ONE REQ'D - MAT'L TYPE 304 STAINLESS STEEL
-2 ONE REQ'D. - MAT'L TYPE 304 STAINLESS STEEL

Figure



(-2) ONE REQ'D. - MAT'L TYPE 304 STAINLESS STEEL

Figure 6

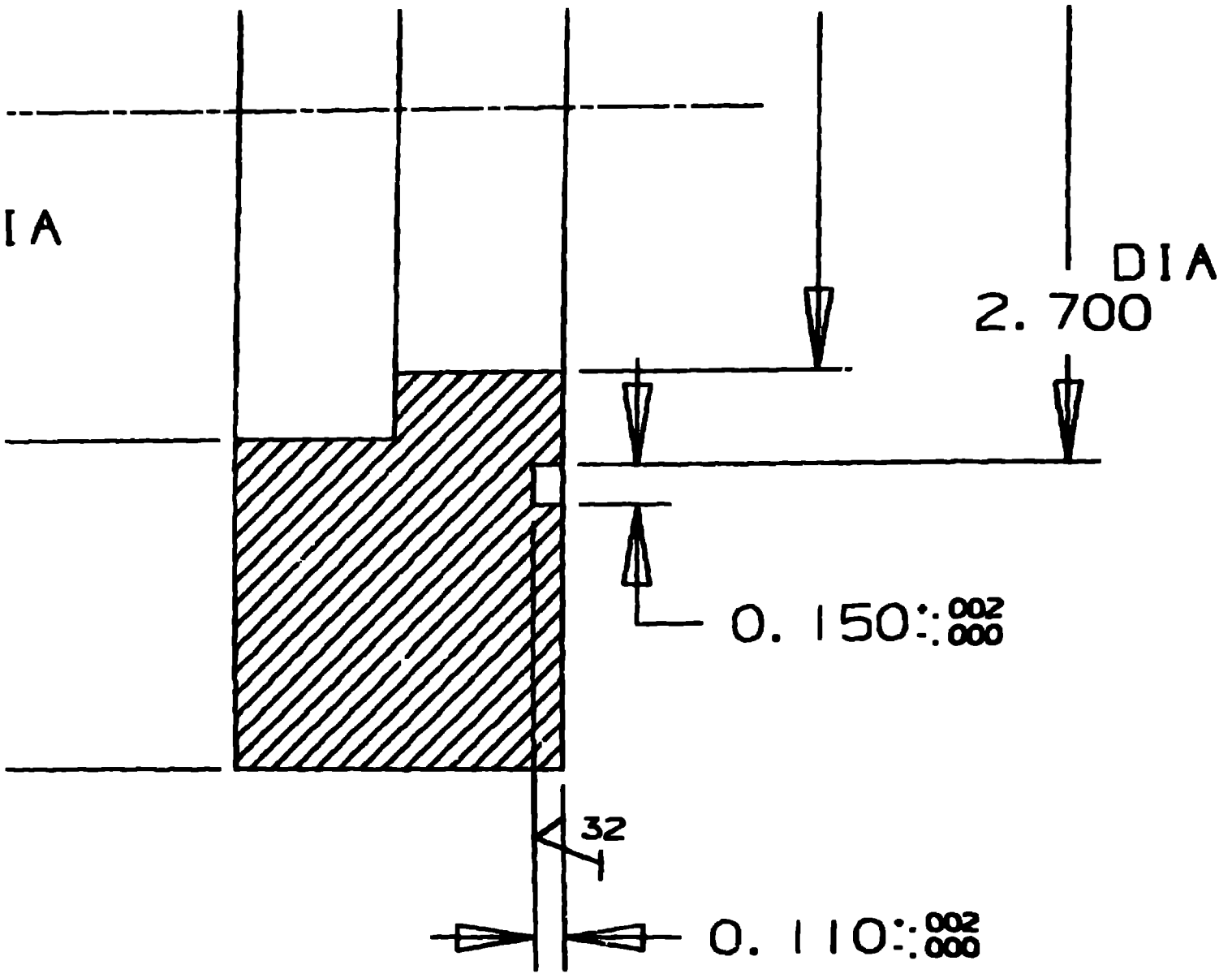


Figure 7

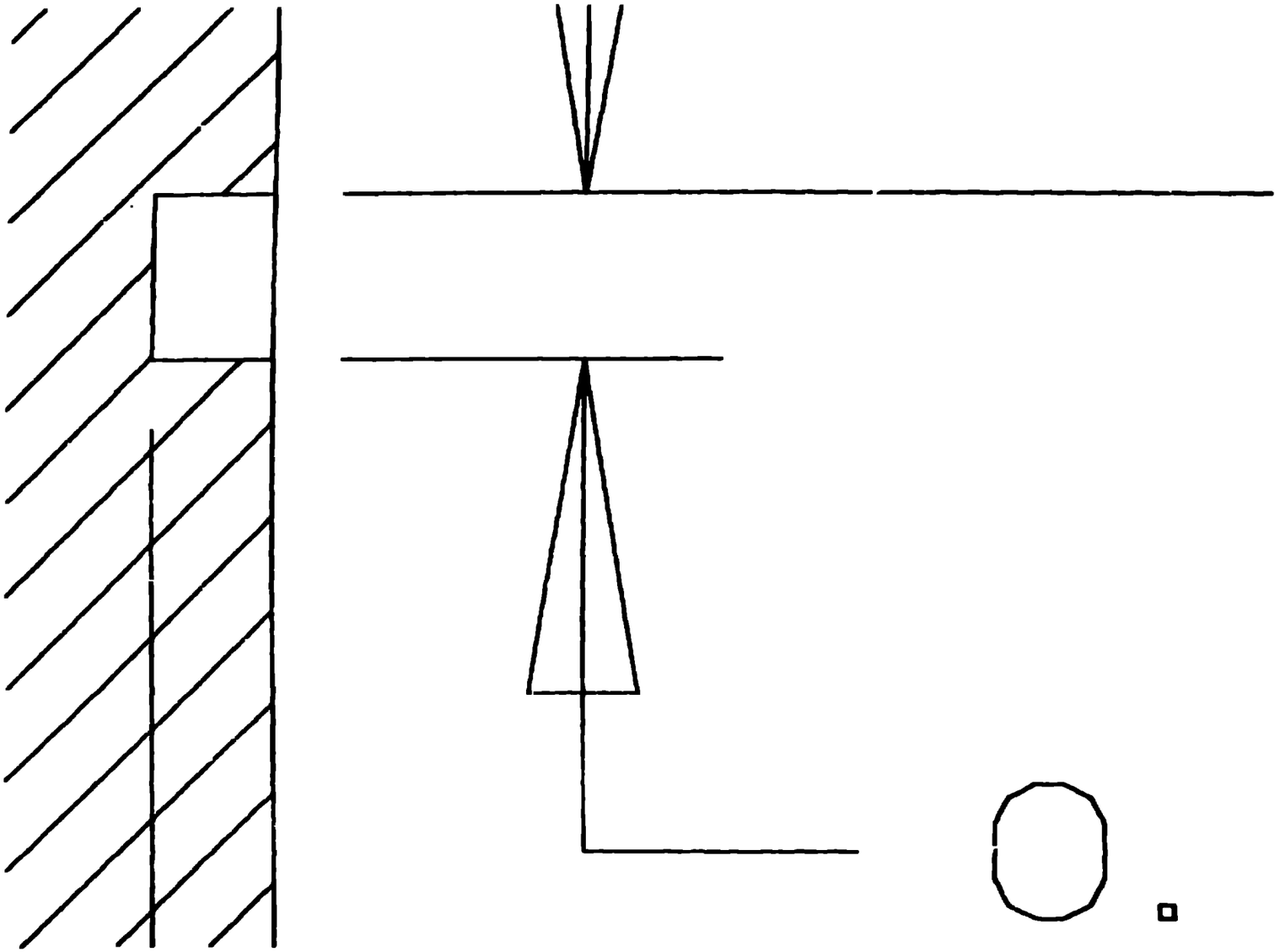


Figure 8

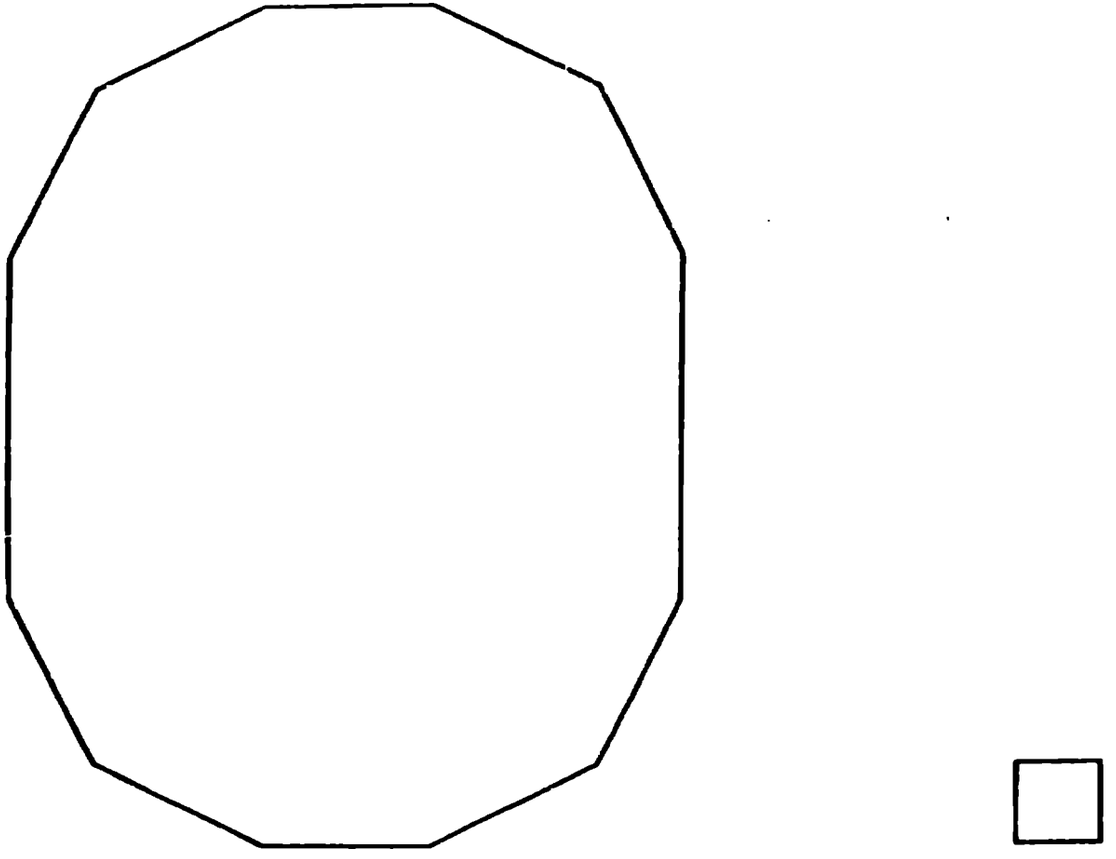


Figure 9

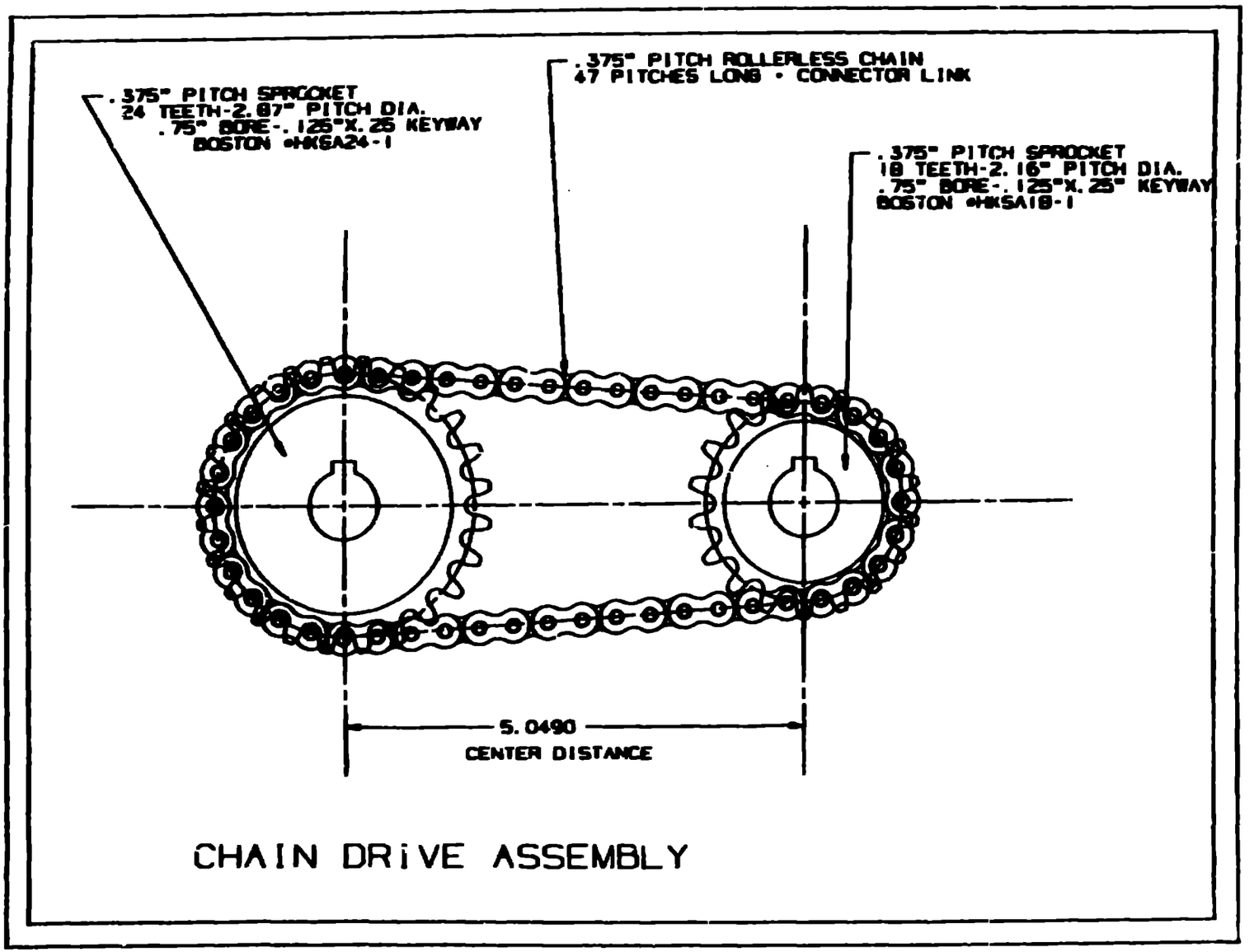
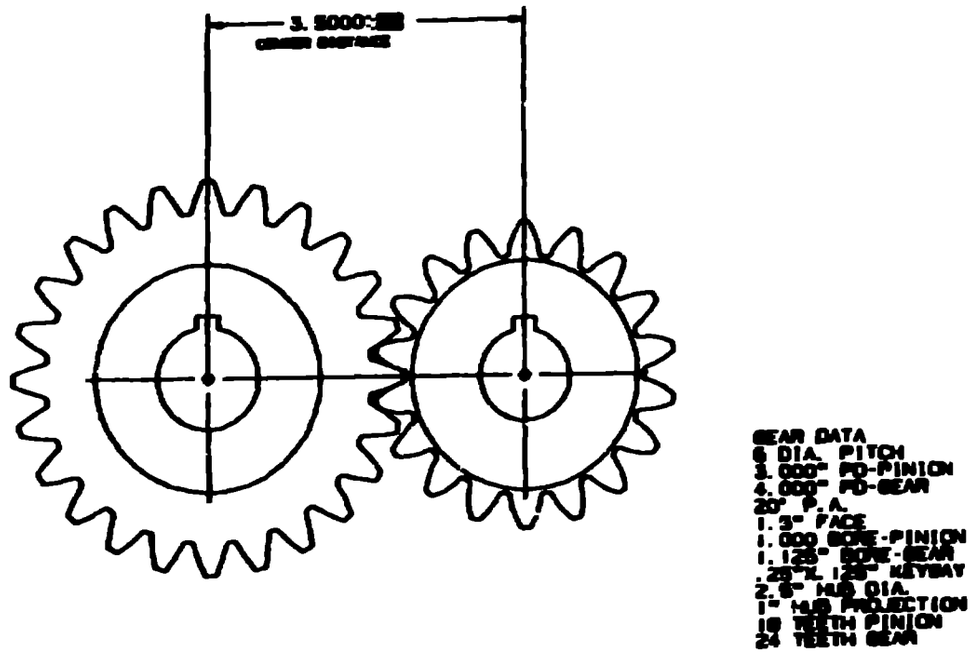

.375" PITCH SPROCKET
24 TEETH-2.87" PITCH DIA.
.75" BORE-.125"X.25 KEYWAY
BOSTON #HKSA24-1
.375" PITCH ROLLERLESS CHAIN
47 PITCHES LONG • CONNECTOR LINK
.375" PITCH SPROCKET
18 TEETH-2.16" PITCH DIA.
.75" BORE-.125"X.25" KEYWAY
BOSTON #HKSA18-1
5.0490
CENTER DISTANCE
CHAIN DRIVE ASSEMBLY

Figure 10



(-1) ONE REQ'D - SPUR GEAR SET

Figure 11

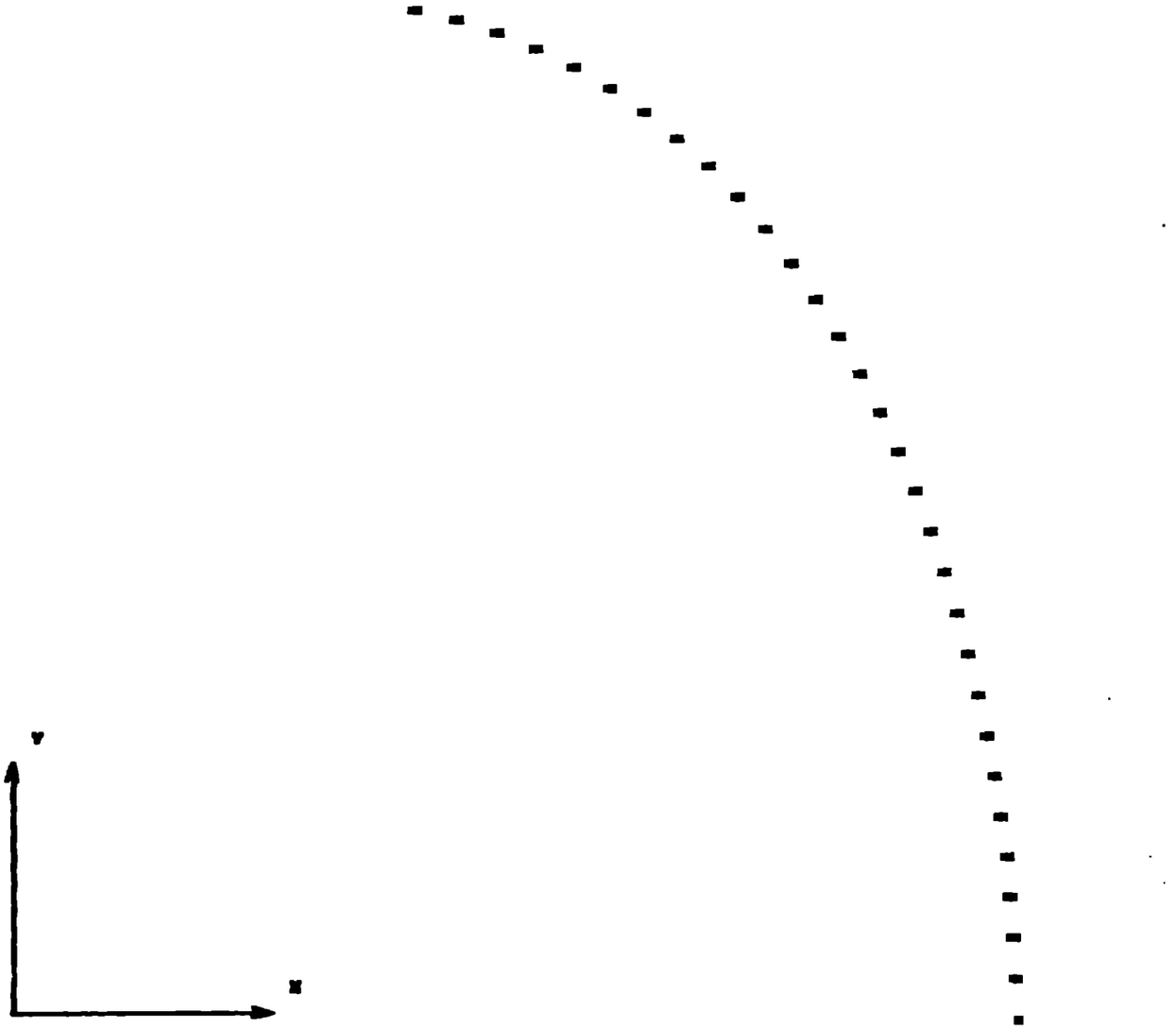


Figure 12

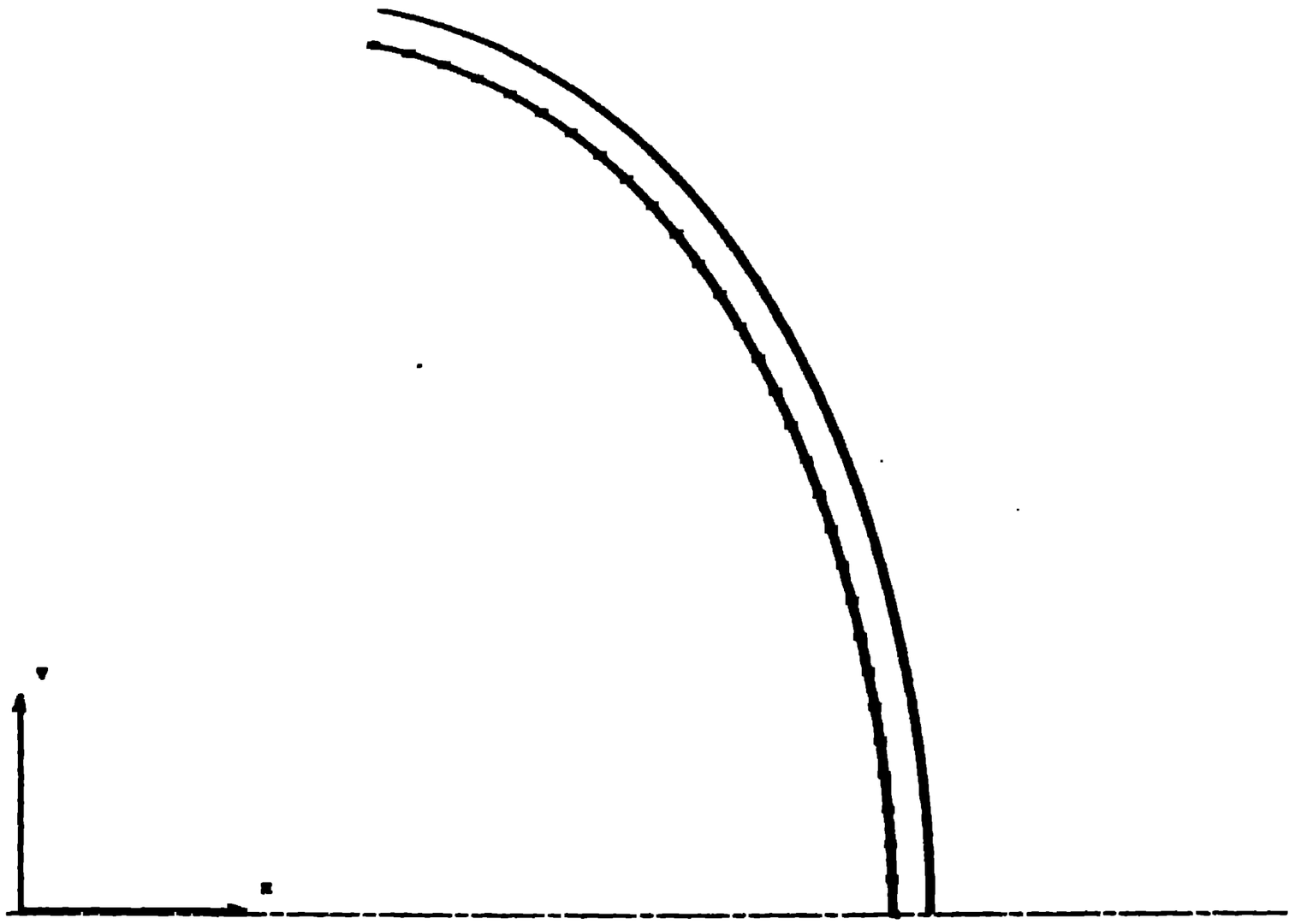


Figure 13

SEG	PT	CURVE POINTS XT	YT
1	1	176.36	0.00
1	2	176.33	0.77
1	3	176.32	1.54
1	4	176.31	2.31
1	5	176.30	3.07
1	6	176.29	3.84
1	7	176.28	4.61
1	8	176.26	5.38
2	1	176.25	6.15
2	2	176.24	7.03
2	3	176.21	7.80
2	4	176.19	8.78
2	5	176.15	9.85
2	6	176.10	10.54
2	7	176.06	11.42
3	1	176.01	12.29
3	2	174.94	13.52
3	3	174.86	14.76
3	4	174.77	15.88
3	5	174.68	17.80
4	1	174.58	18.43
4	2	174.48	19.66
4	3	174.38	20.89
4	4	174.24	22.11
4	5	174.12	23.34
5	1	173.98	24.56
5	2	173.84	25.78
5	3	173.69	27.01
5	4	173.54	28.23
5	5	173.37	29.46
6	1	173.21	30.68
6	2	173.03	31.90
6	3	172.85	33.12
6	4	172.66	34.34
6	5	172.46	35.56
7	1	172.25	36.78
7	2	172.04	38.00
7	3	171.82	39.22
7	4	171.59	40.43
7	5	171.35	41.65
8	1	171.11	42.86
8	2	170.91	43.97
8	3	170.70	44.88
8	4	170.48	45.80
8	5	170.26	46.90
8	6	170.34	47.91
9	1	169.81	48.91
9	2	169.57	49.92
9	3	169.32	50.93
9	4	169.08	51.93
9	5	168.82	52.94

CONTINUED

Figure 14

SEG	PT	CURVE POINTS XT	YT
9	6	168.56	53.84
10	1	168.30	54.84
10	2	168.03	55.84
10	3	167.75	56.84
10	4	167.47	57.84
10	5	167.18	58.83
10	6	166.89	59.83
11	1	166.60	60.82
11	2	166.30	61.82
11	3	166.00	62.81
11	4	165.69	63.80
11	5	165.38	64.80
11	6	165.06	65.80
12	1	164.71	66.80
12	2	164.38	67.85
12	3	164.04	68.83
12	4	163.69	69.82
12	5	163.34	70.80
12	6	162.98	71.77
13	1	162.62	72.75
13	2	162.25	73.73
13	3	161.87	74.70
13	4	161.48	75.67
13	5	161.11	76.64
13	6	160.72	77.61
14	1	160.32	78.57
14	2	159.92	79.54
14	3	159.51	80.50
14	4	159.09	81.46
14	5	158.67	82.42
14	6	158.24	83.37
15	1	157.81	84.32
15	2	157.37	85.27
15	3	156.93	86.22
15	4	156.47	87.17
15	5	156.01	88.11
15	6	155.55	89.05
16	1	155.08	89.98
16	2	154.60	90.92
16	3	154.12	91.85
16	4	153.63	92.78
16	5	153.14	93.71
16	6	152.64	94.63
17	1	152.13	95.55
17	2	151.62	96.47
17	3	151.09	97.38
17	4	150.57	98.29
17	5	150.03	99.19
17	6	149.48	100.08
18	1	148.94	100.98
18	2	148.38	101.86

CONTINUED

Figure 15

SEQ	PT	CURVE POINTS XT	YT
18	3	147.83	102.78
18	4	147.27	103.08
18	5	146.80	104.65
18	6	146.18	105.43
19	1	145.53	106.20
19	2	145.08	107.05
19	3	144.51	107.70
19	4	144.00	108.53
19	5	143.48	108.87
19	6	142.95	110.00
19	7	142.42	110.73
20	1	141.88	111.46
20	2	141.34	112.18
20	3	140.79	112.89
20	4	140.24	113.62
20	5	139.68	114.33
20	6	139.12	115.03
20	7	138.55	115.74
21	1	137.98	116.43
21	2	137.40	117.13
21	3	136.82	117.82
21	4	136.23	118.51
21	5	135.64	119.19
21	6	135.04	119.86
21	7	134.44	120.54
22	1	133.83	121.21
22	2	133.22	121.87
22	3	132.60	122.53
22	4	131.98	123.18
22	5	131.35	123.83
22	6	130.72	124.48
22	7	130.08	125.12
23	1	129.44	125.76
23	2	128.79	126.38
23	3	128.14	127.01
23	4	127.48	127.63
23	5	126.82	128.24
23	6	126.15	128.84
23	7	125.48	129.45
24	1	124.80	130.04
24	2	124.80	130.56
24	3	123.80	131.07
24	4	123.00	131.58
24	5	122.30	132.08
24	6	121.77	132.58
24	7	121.16	133.07
24	8	120.54	133.56
25	1	119.91	134.04
25	2	119.28	134.52
25	3	118.65	134.88
25	4	118.01	135.46

CONTINUE?

Figure 16

SEG	PT	CURVE POINTS XT	YT
[illegible]	5	117.37	135.[illegible]
	6	116.73	136.37
	7	116.06	136.83
	8	115.43	137.27
	1	114.77	137.71
	2	114.12	138.15
	3	113.46	138.58
	4	112.78	139.00
	5	112.12	139.42
	6	111.46	139.83
	7	110.77	140.24
	8	110.09	140.64
	1	109.46	141.03
	2	108.78	141.42
	3	108.03	141.80
	4	107.33	142.17
	5	106.63	142.54
	6	105.93	142.90
	7	105.23	143.25
	8	104.52	143.61
	1	103.80	143.[illegible]
	2	103.08	144.[illegible]
	3	102.37	144.61
	4	101.65	144.94
	5	100.93	145.25
	6	100.20	145.56
	7	99.47	145.86
	8	98.73	146.15
	1	98.00	146.44
	2	97.34	146.69
	3	96.68	146.93
	4	96.01	147.17
	5	95.35	147.40
	6	94.68	147.63
	7	94.01	147.85
	8	93.34	148.06
	9	92.67	148.27
	1	91.98	148.47
	2	91.31	148.66
	3	90.63	148.85
	4	89.96	149.03
	5	89.24	149.21
	6	88.53	149.38
	7	87.80	149.54
	8	87.08	149.69
[illegible]	1	86.41	149.84

Figure 17

NUM	CURV A	CURV B	DELTA CURV	ENERGY
1	-0.01	0.01	-0.01	0.00
2	0.01	0.00	-0.00	0.00
3	0.00	0.00	-0.00	0.00
4	0.00	0.00	-0.00	0.00
5	0.00	0.00	-0.00	0.00
6	0.00	0.01	-0.00	0.00
7	0.01	0.00	0.00	0.00
8	0.00	0.01	-0.00	0.00
9	0.01	0.01	0.00	0.00
10	0.01	0.00	-0.00	0.00
11	0.00	0.01	-0.00	0.00
12	0.01	0.00	0.00	0.00
13	0.00	0.01	-0.00	0.00
14	0.01	0.01	0.00	0.00
15	0.01	0.01	-0.00	0.00
16	0.01	0.01	0.00	0.00
17	0.01	0.01	-0.00	0.00
18	0.01	0.01	0.00	0.00
19	0.01	0.01	0.00	0.00
20	0.01	0.01	0.00	0.00
21	0.01	0.01	-0.00	0.00
22	0.01	0.01	0.00	0.01
23	0.01	0.01	0.00	0.01
24	0.01	0.01	-0.00	0.01
25	0.01	0.01	0.00	0.01
26	0.01	0.01	-0.00	0.01
27	0.01	0.01	0.00	0.01
28	0.01	0.01	-0.00	0.01
29	0.01	0.01	0.00	0.01
30	0.01	0.01	-0.00	0.01

TOTAL ENERGY- 0.14

CONTINUE?

Figure 18

NUM	ALPHA	TAN ANGLE A	TAN ANGLE B
1	-179.19	0.01	0.01
2	-179.66	-0.02	0.02
3	179.95	-0.01	0.01
4	179.69	-0.01	0.01
5	179.80	-0.01	0.01
6	178.82	-0.01	0.02
7	178.54	-0.01	0.01
8	178.16	-0.01	0.00
9	177.98	-0.02	0.02
10	177.79	-0.02	0.01
11	177.51	-0.02	0.02
12	177.51	-0.02	0.02
13	177.42	-0.02	0.02
14	177.51	-0.02	0.02
15	177.60	-0.02	0.02
16	177.78	-0.02	0.02
17	178.23	-0.02	0.02
18	178.59	-0.02	0.02
19	179.13	-0.02	0.02
20	179.94	-0.03	0.03
21	-178.16	-0.03	0.03
22	-178.17	-0.03	0.03
23	-176.91	-0.03	0.03
24	-175.46	-0.03	0.03
25	-173.73	-0.03	0.03
26	-171.91	-0.03	0.04
27	-169.78	-0.04	0.04
28	-167.43	-0.04	0.04
29	-164.87	-0.04	0.04
30	-162.03	-0.04	0.04

CONTINUE?

Figure 19

RUN	SEG LENGTH	SEG ANGLE	EXT ANGLE	SLOPE	NORMAL
1	6.15	90.01	90.01	-14.24	181.98
2	6.15	88.36	1.63	-49.38	181.16
3	6.15	83.00	1.63	-17.55	183.88
4	6.16	85.60	1.63	-18.00	184.78
5	6.17	87.23	1.63	-8.57	186.43
6	6.17	88.87	1.63	-7.06	188.03
7	6.18	100.50	1.73	-6.83	189.73
8	6.20	102.23	1.63	-4.86	191.40
9	6.21	104.05	1.82	-4.29	193.11
10	6.22	105.87	1.82	-3.74	194.90
11	6.23	107.60	1.73	-3.33	196.71
12	6.25	109.61	2.01	-2.87	198.58
13	6.26	111.52	1.92	-2.67	200.56
14	6.27	113.62	2.10	-2.41	202.55
15	6.28	115.72	2.10	-2.18	204.67
16	6.30	117.91	2.19	-1.98	206.77
17	6.31	120.36	2.46	-1.80	209.12
18	6.31	122.73	2.37	-1.63	211.55
19	6.32	125.28	2.55	-1.48	213.95
20	6.32	127.60	2.32	-1.34	216.65
21	6.32	131.40	2.81	-1.21	219.54
22	6.32	134.00	2.60	-1.09	222.46
23	6.32	137.57	3.57	-0.98	225.59
24	6.32	140.72	3.15	-0.87	228.85
25	6.31	144.45	3.73	-0.77	232.56
26	6.31	148.28	3.83	-0.67	236.33
27	6.31	152.48	4.20	-0.57	240.34
28	6.32	156.7	4.30	-0.47	244.80
29	6.34	161.	4.57	-0.38	249.00
30	6.36	165.	4.84	-0.29	253.74
31	0.00	0.00	0.00	-0.20	258.61

LENGTH= 187.85

CONTINUE?

Figure 20

NUM	THETA	RADIUS	X-COORD	Y-COORD
1	0.00	176.35	175.35	0.00
2	2.01	176.37	176.28	6.15
3	4.02	176.44	175.91	12.29
4	6.03	176.55	174.58	18.43
5	8.04	176.71	173.38	24.58
6	10.04	176.90	173.21	30.68
7	12.05	176.14	172.85	36.78
8	14.06	176.40	171.12	42.86
9	16.07	176.71	169.81	48.91
10	18.08	177.04	168.30	54.94
11	20.09	177.30	166.60	60.92
12	22.09	177.77	164.71	66.86
13	24.10	178.15	162.62	72.75
14	26.11	178.54	160.32	78.57
15	28.12	178.88	157.91	84.32
16	30.12	179.20	155.08	89.98
17	32.13	179.65	152.13	95.55
18	34.14	179.95	148.94	100.98
19	36.15	180.22	145.53	106.30
20	38.15	180.43	141.88	111.46
21	40.16	180.54	137.98	116.43
22	42.17	180.56	133.83	121.21
23	44.17	180.47	129.44	125.75
24	46.18	180.24	124.80	130.04
25	48.18	179.85	119.91	134.04
26	50.19	179.27	114.77	137.71
27	52.20	178.49	109.40	141.03
28	54.20	177.47	103.80	143.95
29	56.21	176.21	98.00	146.44
30	58.22	174.66	91.99	148.47
31	60.22	172.80	85.81	149.99

CONTINUE?

Figure 21